https://www.seer.ufal.br/index.php/revistacienciaagricola/index
ISSN: 0103-8699
Doi: 10.28998/rca.21.11796

GROWTH AND PRODUCTION OF LETTUCE IN RESPONSE TO COMPLEMENTARY FERTILIZATION WITH COW URINE

Nelson Licínio Campos de Oliveira[1*], Luciana Costa Rodrigues[1], Rodrigo Amato Moreira[1], Alberto Luiz Ferreira Berto[1], Aldo Luiz Fernandes Dutra[1]

[1] Federal Institute of Northern Minas Gerais (IFNMG) - Campus Januária, Fazenda São Geraldo, S/N Km 06 – 39480-000 - Bom Jardim, Januária - MG, CEP 39480-000, Brazil
***Corresponding author:** Nelson Licínio Campos de Oliveira, nelson.oliveira@ifnmg.edu.br

ABSTRACT: Cow urine is an agricultural input that enables farmers to reduce their dependence on products outside the farm. The aim of this study was to evaluate the effect of cow urine doses applied as complementary fertilization on the production of 'Veneranda' lettuce. The experiment was carried out from 05/21/2018 to 07/03/2018, at IFNMG – Januária Campus, Minas Gerais, Brazil, in an open environment and in organic farming system. The total urine doses applied were 0.0; 1.0; 2.0; 4.0; 8.0; 12.0; 16.0; and 20.0 m^3 ha^{-1}. Solutions were applied to plants on days 10, 13, 16, 25, 28, 31, 35, 38 and 41 after seedling transplantation. At harvest, number of leaves, leaf area, fresh mass of leaves, stem and head, and commercial productivity were evaluated. The growth data of the lettuce crop were submitted to analysis of variance, regression and Pearson correlation. All evaluated characteristics were influenced by cow urine doses and the highest dose (20.0 m^3 ha^{-1}) provided higher values. Plant growth characteristics were positively correlated with commercial yield. Cow urine as a complementary fertilizer, by fertigation in organic farming system, is an alternative for increasing lettuce crop yield.

KEYWORDS: biofertilizer, growth, *Lactuca sativa* L., productivity

CRESCIMENTO E PRODUÇÃO DE ALFACE EM RESPOSTA À ADUBAÇÃO COMPLEMENTAR COM URINA DE VACA

RESUMO: A urina de vaca é um insumo agrícola que possibilita aos agricultores reduzir a dependência de produtos externos à propriedade agrícola. O trabalho foi realizado com o objetivo de avaliar o efeito de doses da urina de vaca aplicadas em adubação complementar na produção de alface 'Veneranda'. O experimento foi conduzido no período de 21/05/2018 a 03/07/2018, na unidade de agroecologia do IFNMG - Campus Januária, em ambiente aberto e em sistema orgânico de cultivo. As doses totais da urina aplicadas foram de 0,0; 1,0; 2,0; 4,0; 8,0; 12,0; 16,0; e 20,0 m^3 ha^{-1}. As soluções foram aplicadas com regador, sobre as plantas, nos dias 10, 13, 16, 25, 28, 31, 35, 38 e 41 após o transplantio das mudas. Na colheita foram realizadas as avaliações do número de folhas, área foliar, massas frescas de folhas, caule e cabeça, e produtividade comercial. Os dados de crescimento de produção da cultura da alface foram submetidos à análise de variância, de regressão e correlação de Pearson. Todas as características avaliadas foram influenciadas pelas doses de urina de vaca, em que a maior dose (20,0 m^3 ha^{-1}) proporcionou maiores valores. As características de crescimento da planta apresentaram correlação positiva com a produtividade comercial. A urina de vaca como adubação complementar, via fertirrigação, no sistema de cultivo orgânico é uma alternativa para aumento da produtividade de alface.

PALAVRAS CHAVE: biofertilizante, crescimento, *Lactuca sativa* L., produtividade

Accepted on February 03, 2023.
Published on April, 2023.

INTRODUCTION

Contemporary conventional horticulture provides significant expansion of vegetable production; however, due to the number of problems caused by this expansion, the search for production alternatives less aggressive to man and the environment, becomes increasingly necessary. With the expectation of preserving natural resources and human health, agriculture itself has the challenge of producing food in a more sustainable and better quality way (Silva et al., 2010).

Agricultural production is increasingly based on alternative production methods, initiatives that are encouraged by public policies, often initiatives by producers themselves, and above all aimed at meeting the demand from consumers for healthier products. In Brazil, in less than a decade, the number of registered organic producers has tripled (MAPA, 2019).

In this context, the use of urine as an agricultural input allows producers to be less dependent on industrialized products, such as fertilizers and synthetic products used to control pests and diseases and hormone stimulants. Urine is a source of nutrients and substances that are beneficial to plants such as phenols and indoleacetic acid (Achliya et al., 2004). This product has no cost to the producer, and when this input is not available on the farm, it has low cost, does not cause health risks to producers and consumers, is easy to apply, being practically ready for use, simply requiring the addition of water (Achliya et al., 2004; Nápolis et al., 2016).

Some researchers have reported positive effects of applications of urine solutions on the dry matter gain of 'Veneranda' lettuce head (Oliveira et al., 2009), on the production of cabbage seedlings (Lovatto et al., 2011), on initial growth, accumulation of dry mass and chlorophylactic pigments of lima bean (Silva et al., 2015), production and mass of jatropha fruits (Nápoles et al., 2018), and eggplant growth and biomass (Araújo et al., 2019).

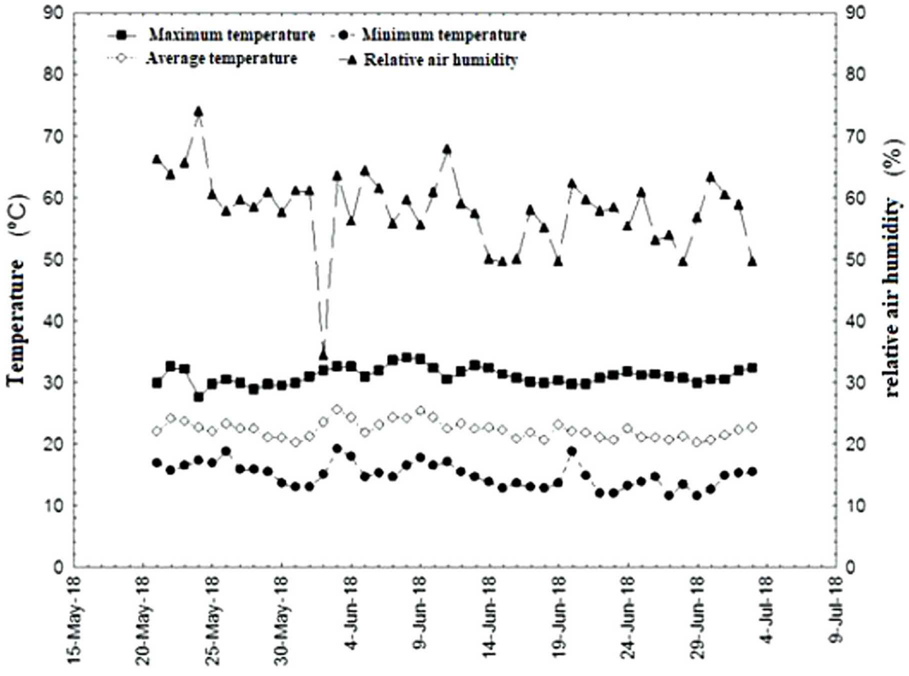
In Brazil, since de production of vegetables is largely conducted by family farming, studies are needed to enhance the diversification of the use of alternative sources in organic fertilization. Among these sources, cow urine can be applied to crops via fertigation as a form of supplementary fertilization. It is important to point out that the appropriate cow urine concentration to be applied varies according to the species, cultivar, climate and crop management.

Given the above, this study was carried out with the aim of evaluating the effect of doses of cow urine solutions applied as complementary fertilization on the growth and production of 'Veneranda' lettuce.

MATERIAL AND METHODS

The experiment was carried out in an open environment at the organic horticulture sector in the Agroecology Unit of the Federal Institute of Northern Minas Gerais (IFNMG), Campus Januária, Minas Gerais, 15° 28′ 55″ S; 44° 22′ 41″ W, altitude of 474 m a.s.l.), in the period from 05/21/2018 to 07/03/2018. The Köppen-Geiger climate classification indicates Aw climate, that is, tropical climate with dry winter (Reboita et al., 2015). During the experiment, the minimum, maximum and average air temperatures and relative air humidity were recorded (Figure 1).

Figure 1. Daily average minimum, average and maximum temperature and relative air humidity values under field conditions during the experiment. IFNMG, Januária, MG, 2018.



The experiment was conducted in a randomized block design, with eight treatments (0; 1; 2; 4; 8; 12; 16; 20 m^3 ha^{-1} of cow urine) and four replicates. The experimental unit consisted of four longitudinal rows of 1.50 m in length, with plants spaced 0.30 x 0.30 m, totaling 20 plants and an area of 1.8 m^2, and the six central plants of the two central rows were considered as useful plants.

Cultivation was carried out in beds measuring 15 x 1.2 x 0.3 m (length x width x depth). The soil in the area was classified as loam-sandy and the soil chemical and physical analyses were carried out at 0-20 and 20-40 cm layers (Table 1).

Table 1. Values of chemical and physical analysis of soil samples before organic planting fertilization. Januária, MG, IFNMG, 2018

Chemical Characteristics	**0-20 cm layer**	**20-40 cm layer**
Parameters	**Values**	**Values**
Actual soil density (g cm^{-3})	2.5	2.5
Density porosity	52.4	51.8
pH in water	7.0	6.5
pH in $CaCl_2$	6.5	5.9
O.M. (dag kg^{-1})	0.2	0.7
P Resin (mg dm^{-3})	21.4	10.0
C Org (%)	0.2	0.4
P (mg dm^{-3})	26.7	10.9
K (mg dm^{-3})	82.6	47.7
S (mgdm^{-3})	3.2	1.8
Ca^{2+} (cmolc dm^{-3})	1.8	1.5
Mg^{2+} (cmolc dm^{-3})	0.7	0.6
Al^{3+} (cmol dm^{-3})	0.1	0.1
H+Al (cmolc dm^{-3})	0.2	0.7
CEC (cmolc dm^{-3})	2.9	2.9
V (%)	93	76
m (%)	0	0
Ca/Mg	2.6	2.5
Ca/K	8.5	12.3
B (mg dm^{-3})	0.3	0.2
Zn (mg dm^{-3})	2.4	0.1
Fe (mg dm^{-3})	13.9	14.1
Mn (mg dm^{-3})	42.0	26.4
Cu (mg dm^{-3})	0.7	0.6
CE (μS cm^{-1})	104.4	276.2
Na^+ (cmolc dm^{-3})	0.2	0.1
P rem. (mg dm^{-3})	53.1	51.7
Physical Characteristics	**Values**	**Values**
Silt (%)	9.9	9.1
Clay (%)	11.0	13.0
Sand (%)	79.1	77.9

Based on the soil analysis, liming was not necessary due to the methodology used in the state of Minas Gerais to neutralize aluminum and increase calcium and magnesium levels (Alvarez & Ribeiro, 1999).

Lettuce seedlings 'Veneranda' cultivar were produced in polystyrene trays containing 128 cells. Trays were previously washed with neutral detergent, and soon after, disinfestation was carried out with 2% sodium hypochlorite solution and dried in the shade. To fill the trays, earthworm humus substrate was used.

Sowing was performed on 04/19/2018 using one seed per cell. Seedlings were produced in a protected environment with daily irrigation using watering can with fine sieve, checking their humidity and turgor status.

The characteristics of the 'Veneranda' cultivar are: light green coloration, cycle between 60 and 70 days after sowing, excellent commercial quality and resistance to bolting, an important characteristic for hot regions such as northern state of Minas Gerais.

Planting fertilization in beds was carried out five days before transplanting, following recommendation of

Fontes (1999), using bovine manure (Table 2) tanned in the equivalent amount (1.22 kg m^{-2}), referring to 7.65 t ha-1 of manure dry matter, 18 g per plant of MC 60 YOORIN Master 1 Si (Table 3) per plant.

Table 2. Values of the chemical and physical analysis of tanned bovine manure used in the experiment. Januária, MG, IFNMG, 2018

Physical - Chemical Results	Values
Humidity (%)	14.5
pH in $CaCl_2$	8.65
M.O (%)	28.2
C.O (%)	16.37
Total nitrogen – N (%)	0.72
Total phosphorus - P_2O_5 (%)	0.77
Total potassium – K_2O (%)	1.2
C/N ratio	22.74
Total calcium -Ca (%)	1.20
Total magnesium – Mg (%)	0.23
Total sulfur - S (%)	0.008
Total boron - B (%)	0.23
Total copper - Cu (%)	0.038
Total manganese -Mn (%)	0.0004
Iron Fe (%)	0.42
Zinc total - Zn (%)	0.0105

Analysis performed according to the technical standard used: IN 05/2007 – MAPA

Table 3. Chemical composition of Yoorin Master 1S phosphate fertilizer used in the experiment. Januária, MG, IFNMG, 2018

Phosphorus (P_2O_5)		Guarantees %							
Total	Citric Acid	Ca	Mg	S	B	Cu	Mn	Si	Zn
16.0	12.0	12.0	6.5	6.0	0.1	0.05	0.3	9.0	0.55

Information provided by company Mineração Curimbaba Ltda

Seedlings were transplanted to beds 31 days after sowing, when seedlings had four definitive leaves. The operation took place in the afternoon between 04:00 pm and 06:00 pm. In the first four days after transplanting, 50% shading was used to attenuate solar incidence.

Irrigations were performed by microsprinkler, respecting the application intervals of cow urine solutions of 24 hours, and their management was defined according to soil moisture and plant water conditions. The water used for irrigation had the chemical composition shown in (Table 4). The management of spontaneous plants on beds was carried out manually, at weekly intervals.

Table 4. Chemical analysis of the water used in fertigation. Januária, MG, IFNMG, 2018

Chemical characteristics	Unit	Value
pH at 25 °C	pH	7.5
CE – electrical conductivity	dS m^{-1}	0.21
Sodium (Na^+)	mg L^{-1}	2.9
Potassium (K^+)	mg L^{-1}	1.5
Calcium (Ca^{2+})	mg L^{-1}	244.6
Magnesium (Mg^{2+})	mg L^{-1}	17.8
Chlorides (Cl^-)	mg L^{-1}	35.5
Carbonates (CO_3^{2-})	mg L^{-1}	0.0
Bicarbonate (HCO^-_3)	mg L^{-1}	126.2
RAS[1]	$mmol_c$ L^{-1}	0.05
Water hardness	mg$CaCO_3$ L^{-1}	262.4

[1] Sodium adsorption ratio

Urine was collected from cows in the lactation phase, in the cattle sector of the Federal Institute of Northern Minas Gerais, Campus Januária, MG. Collection was performed at the time of milking for a period of 30 consecutive days in a herd of 20 healthy cows. The collected urine was kept in disinfected and closed plastic bottles to avoid loss of ammonia, being kept in protected environment. After collecting all the urine needed for the experiment, a 500-ml urine sample was removed from plastic bottles and sent to the laboratory for physicochemical analysis (Table 5).

Table 5. Chemical analyses of urine used in the experiment after thirty-four days of storage in hermetically sealed plastic container. Januária, MG, IFNMG, 2018

Physical - Chemical Results	Values
pH in $CaCl_2$	8.87
M.O (%)	3.0
Density (g cm^{-3})	1.0
Oxidisable Organic Carbon (%)	1.79
Total nitrogen (%)	0.42
Total potassium - K_2O (%)	1.2
Total phosphorus (%)	0.02
C/N ratio	3.6
Total magnesium - Mg (%)	0.026
Total sulfur - S (%)	0.051
Total calcium - Ca (%)	0.0094
Total boron - B (%)	0.009
Total copper - Cu (%)	0.034
Total manganese - Mn (%)	0.0004
Total chlorine - Cl (%)	0.46
Total molybdenum - Mo (mg kg^{-1})	0.01
Total zinc - Zn (%)	0.038
Total iron - Fe (%)	0.025
Total cobalt - Co(mg kg^{-1})	0.01
Sodium - Na (%)	0.0375
Total aluminum - Al (%)	0.05

Technical standard used: IN 05/2007 – MAPA

Cow urine doses were applied via fertigation on the plant with a plastic watering can with capacity of ten liters of solution on days 10, 13, 16, 25, 28, 31, 35, 38 and 41 after transplanting, according to the absorption curve of lettuce for nutrients nitrogen and potassium (Katayama, 1993).

The respective dilutions are presented in Table 6. Urine doses were diluted in 9 liters of water and applied for each m^2 of bed. The division of the urine volume used in fertigation was distributed according to the days after transplanting: 10, 13 and 16 (25%); 25, 28 and 31 (37.5%) and at 35, 38 and 41 (37.5%), according to the absorption curve of elements nitrogen and potassium in the lettuce crop cycle (Katayama, 1993). The highest cow urine solution concentration was 3.7%, applied on days 25, 28, 31, 35, 38 and 41 days after transplanting. Applications were carried out from 04:00 pm onwards, and on that day, irrigation was suspended, resuming 24 hours after the application of solutions containing urine doses. The amounts of elements present in each applied dose are presented in (Table 7).

Harvest was carried out on 07/03/2018, 44 days after transplanting, when plants showed maximum leaf development (Scalon, 2017).

In six plants representative of the useful area, the following characteristics were evaluated: number of leaves $plant^{-1}$ (NLP), leaf area (LA), fresh leaf mass (FLM), fresh stem mass (FSM), fresh head mass (FHM) and commercial productivity (PROD).

Table 6. Treatments, total cow urine volumes applied in fertigation per hectare1 and per m^2 of bed, in the days after transplanting (DAT). Januária, MG, IFNMG, 2018

Treatments	Volume (m^3 ha^{-1})	Volume (ml m^{-2})	Volume (ml) of urine applied per m^2 of bed in the days after transplanting (DAT)[8]								
			10	13	16	25	28	31	35	38	41
1*	--	--	--	--	--	--	--	--	--	--	--
2	1	133	11.08	11.08	11.08	16.62	16.62	16.62	16.62	16.62	16,62
3	2	267	22.25	22.25	22.25	33.37	33.37	33.37	33.37	33.37	33,37
4	4	533	44.42	44.42	44.42	66.62	66.62	66.62	66.62	66.62	66,62
5	8	1.066	88.83	88.83	88.83	133.25	133.25	133.25	133.25	133.25	133,25
6	12	1.600	133.33	133.33	133.33	200.00	200.00	200.00	200.00	200.00	200,00
7	16	2.133	177.75	177.75	177.75	266.62	266.62	266.62	266.62	266.62	266,62
8	20	2.667	222.75	222.75	222.75	333.37	333.37	333.37	333.37	333.37	333,37

[1] Planted area in 1.0 ha: 7500 m2 of beds. *Irrigation water only.

Table 7. Amounts of total elements applied via fertigation in kg ha^{-1} of cow urine in lettuce. Januária, MG, IFNMG, 2018

Elements	Amount of elements per treatments urine ha^{-1}						
	$1m^3$	$2m^3$	$4m^3$	$8m^3$	$12m^3$	$16m^3$	$20m^3$
N (kg)	4.2	8.4	16.8	33.6	50.4	67.2	84.0
P (kg)	0.2	0.4	0.8	1.6	2.4	3.2	4.0
K (kg)	12.0	24.0	48.0	96.0	144.0	192.0	240
Mg (kg)	0.26	0.52	1.04	2.08	3.12	4.16	5.2
Ca (kg)	0.094	0.188	0.376	0.752	1.128	1.504	1.88
S (kg)	0.51	1.02	2.04	4.08	6.12	8.16	10.2
Cl (kg)	4.6	9.2	18.4	36.8	55.2	73.6	92.0
B (kg)	0.09	0.18	0.36	0.72	1.08	1.44	1.8
Cu (kg)	0.34	0.68	1.34	2.72	4.08	5.44	6.8
Mn (kg)	0.004	0.008	0.016	0.032	0.048	0.064	0.008
Fe (kg)	0.25	0.5	1.0	2.0	3.0	4.0	5.0
Al (kg)	0.5	1.0	2.0	4.0	6.0	8.0	10.0
Na(kg)	1.0	2.0	4.0	8.0	12.0	16.0	20.0

Planted area in 1.0 ha: 7500 m2 of beds, and population of 83,330 plants.

The number of leaves per plant was obtained by counting all leaves present on the head with minimum size of 5 cm in length.

The leaf area of the harvested plant was estimated. Thus, five leaves were removed from each plant at different development stages. Then, a disk was removed from the leaf blade from the central part of each leaf using a metal cylinder with internal area of 4.15 cm^2. Discs were dried in an oven with forced ventilation at 65 °C until constant mass expressed in g $plant^{-1}$. The leaf area was determined by the equation:

$LA = ND*DA*DLM/DDM$

Where: LA = leaf area (cm^2);

ND = number of sampled disks;

DA = disk area (cm^2);

DLM = dry leaf blade mass (g);

DDM = dry disk mass (g).

Fresh leaf mass was obtained by measuring the mass of head leaves without the stem, after harvesting, expressed in g $plant^{-1}$.

Fresh stem mass was obtained by measuring the mass of the stem present in the head, without leaves, immediately after harvesting, expressed in g $plant^{-1}$.

Commercial productivity was obtained by multiplying the average fresh head mass by the population of plants present in an area equivalent to 7,500 m^2 (useful area), expressed in Mg ha^{-1}.

At the end of the experiment, soil samples were taken from all treatments for chemical analysis in order to compare soil elements before and after planting fertilization and complementary fertilization (Table 8).

Lettuce growth and production data were submitted to analysis of variance, regression and Pearson's correlation. For the selection of regression models, as a function of cow urine doses, the criterion of greatest coefficient significance of parameters and biological explanation was considered. To infer the degree of interdependence between dependent variables, the Pearson's linear correlation analysis was performed.

Table 8. Results of chemical analysis of soil samples before organic planting fertilization and complementary fertilization using cow urine doses. Januária, MG, IFNMG, 2018

Chemical Characteristics	Before planting and complementary fertilization		After harvesting															
			Cow urine doses in m^3 ha^{-1}															
			0		1		2		4		8		12		16		20	
Soil layer (cm)	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40	0-20	20-40
pH in waeter (1:2,5) [1]	7,0	6.5	8.20	7.92	8.24	7.63	8.17	7.61	8.15	7.56	8.21	7.71	8.15	7.69	8.16	7.45	8.22	7.67
P (mg dm^{-3}) [2]	26,7	10.9	38.9	32.8	38.0	16.7	34.4	16.0	36.4	18.2	35.2	18.4	94.9	25.3	57.7	32.3	146.8	28.3
P-rem (mg L^{-1}) [14]	53,1	51.7	17.5	17.1	17.4	17.0	17.6	16.8	17.5	16.8	17.6	16.9	25.8	25.7	26.6	25.9	26.8	26.0
K^+ (mg dm^{-3}) [2]	82,6	47.7	95.0	54.0	65.0	41.0	79.0	56.0	82.0	53.0	76.0	67.0	76.0	67.0	110.0	45.0	111.0	61.0
Na^+ (cmolc dm^{-3}) [2]	0,2	0.1	0.09	0.05	0.07	0.04	0.06	0.05	0.06	0.05	0.06	0.05	0.06	0.04	0.06	0.04	0.08	0.05
Ca^{2+} (cmolc dm^{-3}) [3]	1,8	1.5	4.0	2.9	4.3	2.2	3.7	2.2	3.8	2.1	4.3	2.1	3.9	2.3	3.7	2.1	4.1	2.7
Mg^{2+} (cmolc dm^{-3}) [3]	0,7	0.6	0.7	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.7	0.8	0.7	0.9	0.8
S (mg dm^{-3}) [6]	3,2	1.8	3.1	2.2	2.6	2.2	2.5	2.3	3.0	2.2	2.4	2.1	2.3	1.9	2.2	2.1	2.3	2.2
Al^{3+} (cmolc dm^{-3}) [3]	0,1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H + Al (cmolc dm^{-3}) [4]	0,2	0.7	0.72	0.87	0.73	0.93	0.77	0.99	0.79	0.99	0.8	0.97	0.83	0.99	0.92	1.18	0.89	1.04
SB (cmolc dm^{-3}) [7]	2,9	2.3	5.0	3.7	5.2	2.9	4.6	3.0	4.7	2.9	5.2	2.9	5.0	3.3	4.9	3.0	5.4	3.7
CEC(t) (cmolc dm^{-3}) [8]	3,0	2.4	5.0	3.7	5.2	2.9	4.6	3.0	4.7	2.9	5.2	2.9	5.0	3.3	4.9	3.0	5.4	3.7
CEC(T) (cmolc dm^{-3}) [9]	3,1	3.0	5.7	4.5	5.9	3.8	5.4	4.0	5.5	3.9	6.0	3.8	5.8	4.3	5.8	4.2	6.3	4.7
V (%) [10]	93,0	76.0	87.4	80.8	87.7	75.6	85.6	75.3	85.6	74.6	86.7	74.7	85.6	76.9	84.1	71.8	85.8	77.9
m (%) [11]	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ESP [12]	6,4	3.3	1.5	1.1	1.1	1.0	1.1	1.1	1.0	1.2	1.0	1.2	1.0	0.9	1.0	0.9	1.2	0.8
OM (dag kg^{-1}) [13]	0,2	0.7	1.8	1.2	1.8	0.8	1.6	0.8	1.8	0.8	1.6	0.8	1.6	0.9	1.6	0.7	1.6	1.1
Zn (mg dm^{-3}) [2]	2,4	0.1	8.27	4.24	4.14	1.87	2.66	3.52	3.81	0.74	2.67	1.37	3.08	1.14	2.94	2.08	10.19	2.16
Fe (mg dm^{-3}) [2]	13,9	14.1	34.0	25.9	21.0	26.7	21.7	26.1	19.2	23.6	21.3	22.8	14.8	15.2	11.2	15.4	29.5	20.9
Mn (mg dm^{-3}) [2]	42,0	26.4	67.2	58.1	62.3	47.7	61.7	48.0	59.6	45.1	59.4	44.6	60.8	47.5	54.5	40.3	62.6	52.8
Cu (mg dm^{-3}) [2]	0,7	0.6	1.3	0.8	0.6	0.6	0.2	0.6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
B (mg dm^{-3}) [5]	0,3	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CE dS m^{-1}	0,10	0.28	0.11	0.09	0.11	0.06	0.10	0.06	0.11	0.06	0.11	0.06	0.11	0.07	0.12	0.07	0.12	0.08

[1] pH in water, KCl and $CaCl_2$ – ratio 1:2.5; [2] P, Na, K, Fe, Zn, Mn and Cu Mehilch extractor 1; [3] Ca, Mg and Al extractor: KCl: 1 mol Ll^{-1}; [4] H + Al: calcium acetate extractor 0.5 mol L^{-1} – pH 7.0; [5] B: hot water extractor; [6] S: extractor – monocalcium phosphate in acetic acid; [7] SB: sum of exchangeable bases; [8] CEC (t): effective cation exchange capacity; [9] CEC (T): Cation exchange capacity at pH 7.0; [10] V: base saturation index; [11] m: aluminum saturation index; [12] ESP: exchangeable sodium percentage; [13] Org. Mat. (OM): C.org x 1.724 – Walkley-Black; and [14] P-rem: remaining phosphorus.

RESULTS AND DISCUSSIONS

The soil pH after harvesting at both layers under study, in general, showed higher values (Table 8). In 0-20 and 20-40 cm layers, pH of 7.0 and 6.5 was verified before planting, respectively, and after harvesting, pH ranged from 8.15 to 8.24 and from 7.45 to 7.92, respectively (Table 8). Considering that soils were only applied of pure water without the use of cow urine, the soil pH in the 0-20 cm layer before the application of treatments was 7.0 and after harvest, pH increased to 8.20. It was also verified that in the 20-40 cm layer, the same pH behavior was verified, ranging from 6.5 to 7.92.

In view of the above, the increase in pH of soil layers should not be attributed to the urine volumes applied, but to the chemical composition of the irrigation water (Table 4), where bicarbonate (HCO_{-3}) content was 126.2 mg L^{-1}, which, according to Vieira and Ramos (1999), is classified as medium damage to the quality of irrigation water, contributing to increase hydroxyls in the soil solution and, consequently, increase soil pH (Souza et al., 2007). This chemical characteristic is an important factor, as it can interfere with root growth and the activity of microorganisms in the rhizosphere, influencing the availability of nutrients for plants (Raij, 2011).

The exchangeable sodium percentage (ESP) before planting in 0-20 and 20-40 cm layers were 6.4 and 3.3 %, respectively, and after harvest before applications of cow urine doses varied from 1.0 to 1.5 and from 0.8 to 1.1 %, respectively. This fact can be explained by plant absorption and the loam - sandy soil texture, irrigation and sodium leaching (Freire and Freire, 2007).

The electrical conductivity before planting in 0-20 and 20-40 cm layers were 0.10 and 0.28 dSm^{-1}, respectively, and after harvest before applications of urine doses ranged from 0.10 to 0.12 and from 0.6 to

0.8 dSm^{-1}, respectively. These electrical conductivity values after applications probably occurred due to the presence of other elements in cow urine.

Variations in pH, exchangeable sodium percentage and electrical conductivity at the end of the experiment, for all applied urine doses, according to Salassier (2006), are within normal ranges according to the classification of saline and alkaline soils, where the pH of soils showed values ranging from 4.0 to 8.5; exchangeable sodium percentage less than 15% and electrical conductivity less than 4.0 dSm^{-1} at 25 °C.

In this context and considering that the highest urine dose (20 m^3 ha^{-1}) provided soil with 20 kg of sodium ha^{-1} (Table 7) and did not change the soil salinity characteristics, remaining in the normal classification, and not interfering with lettuce development, the capacity of this vegetable to be considered semi-tolerant to the soil exchangeable sodium concentration stands out (Salassier, 2006).

All evaluated characteristics were influenced by the applied urine doses, and presented values of better significance of coefficients for the linear type equation.

The highest urine dose (20.0 m^3 ha^{-1}) supplied soil in kg ha^{-1}: 84.0 of N; 4.0 of P; 240 of K; 1.88 Ca; 5.2 of Mg; 10.2 of S; 6.8 Cu; 5.0 Fe; 1.8 of B and 0.008 of Mn (Table 7). According to Fontes (1999), the recommendation for complementary fertilization for lettuce in medium fertility soils is 120 and 75 kg ha^{-1} of N and K, respectively, for production of 21 Mg ha^{-1}.

Applications of urine doses in complementary fertilization exerted a positive influence on the growth and production of lettuce 'Veneranda' cultivar (Table 9).

Table 9. Regression equations for number of leaves per plant (NLP), leaf area (LA), fresh leaf mass (FLM), fresh stem mass (FSM) and fresh head mass (FHM) and marketable productivity (PROD) of 'Veneranda' lettuce as a function of cow urine doses applied (0 to 20 m^3 ha^{-1}). Januária, MG, IFNMG, 2018

Variable	Equation	R^2	Dose	Ymax / unit
NLP	$\hat{y}$ = 19.7586 + 0.1824x	0.72	20	23.41 un
LA	$\hat{y}$ = 4.830.8286 + 273.9873x	0.79	20	10.310.57 cm^2 $plant^{-1}$
FLM	$\hat{y}$= 230.8457 + 15.8713x	0.94	20	548.27 g $plant^{-1}$
FSM	$\hat{y}$ = 9.5287 + 1.1016x	0.96	20	31.56 g $plant^{-1}$
FHM	$\hat{y}$ = 240.3744 + 16.9729x	0.94	20	579.83 g $plant^{-1}$
PROD	$\hat{y}$ = 20.0311 + 1.4143x	0.94	20	48.32 Mg ha^{-1}

In the use of liquid bovine biofertilizer in the cultivation of lettuce 'Vanda' cultivar, Silva (2018) found that the number of leaves per plant ranged from 36.87 to 47.81 at concentrations of 20% and 80%, respectively. Dalri et. al (2014) studied the effect of fertigation with concentrated vinasse on lettuce development and found the highest number of 23.0 leaves per plant at dose of 2.98 m^3 ha^{-1}. Therefore, it appears that the number of leaves per plant is conditioned by the chemical composition of macro and micronutrients and substances likely beneficial to plants, such as phenols and indoleacetic acid (Achliya et al., 2004) present in the biofertilizers used.

The highest number of leaves per plant was observed in plants that received the urine dose of 20 m^3 ha^{-1}, which possibly provided the highest amount of nutrients (Table 7), which are essential for crop development, justifying that elements Cl, Al and Na did not prevent the increase in productivity as a function of applied urine doses.

It is noteworthy that in lettuce production, the characteristic number of leaves is also associated with the temperature of the growing environment and the photoperiod (Oliveira et al., 2004), thus defining the lettuce production that is marketed in the fresh form. However, this variable may not reflect on crop performance, considering that the plant may have many leaves, but with reduced size, which visually is not attractive to consumers.

The application of 20.0 m^{-3} ha^{-1} of urine promoted increases of 118.46% in the number of leaves per plant, 113.44% in leaf area; 137.50% in fresh leaf mass; 231.21% in the fresh stem mass; 141.22% in fresh head mass and 142.22% in commercial productivity of lettuces in relation to control treatment plants (Table 9).

The leaf areas of plants obtained in this experiment, in relation to the applied urine doses, were higher than those found by Freire et al. (2017). These authors worked with the phytotechnical performance and chlorophyll contents of lettuces produced with cow urine fertilization and obtained leaf areas for the 'Elba' cultivar of 3,155.5 cm^2 and 2,106.1 cm^2 for 'Rosabela' cultivar at concentrations of 2.2 and 2.4%, respectively. According to Monteiro et al. (2005), the leaf area is an important vegetative characteristic, because it allows studying factors such as ecological adaptation; competition with other species and results of the management used, in addition to being a characteristic used to determine the leaf area index, which is commonly used in agronomic and physiological studies in order to evaluate the growth and development of plants. In lettuce, it is one of the most important factors because leaves are the products to be consumed.

Alencar et al. (2012) evaluated the effect of bovine urine application intervals (5, 10, 15 days) at concentration of 1%, and volume of 150 mL of solution per plant in lettuce production in protected environment and observed the following plant behavior: the highest fresh leaf mass (151.8 g $plant^{-1}$) in the 15-day cow urine application interval, fresh stem mass of 25.74 g $plant^{-1}$ in the 5-day cow urine application interval.

Regarding productivity of 'Elba' and 'Rosabela' lettuce cultivars, Freire et al. (2017) found values of 12.2 and 9.4 Mg ha^{-1} at cow urine concentrations of 2.2 and 2.4%, respectively. This difference between studies may be associated with factors such as cultivar, climate, planting time, concentration of essential elements and volume of applied solution.

For all variables analyzed in response to the application of cow urine as a supplementary fertilizer, lettuce development was justified by the input of nutrients present in cow urine (Tables 5 and 7).

Pearson's linear correlation showed high degree of interdependence among growth characteristics under study. Variables number of leaves, leaf area, fresh leaf, stem and head masses are positively correlated with marketable productivity, following a pattern of responses to urine doses (Table 10).

Table 10. Pearson correlation between variables analyzed in the experiment (FHM - fresh head mass, FLM - leaf, FSM - and stem; NLP- number of leaves $plant^{-1}$; LA - leaf area, PROD - marketable productivity). Januária, MG, IFNMG, 2018

	FHM	FLM	FSM	NLP	LA	PROD
FHM	1.00					
FLM	0.99**	1.00				
FSM	0.98**	0.97**	1.00			
NLP	0.84**	0.84**	0.82**	1.00		
LA	0.75**	0.75**	0.76**	0.65**	1.00	
PROD	1.00**	0.99**	0.98**	0.84**	0.75**	1.00

**Significant at 1%

It is noteworthy that that the use of cow urine as a supplementary fertilizer is of paramount importance for the development of agriculture in current world conditions, due to the excess of agrochemicals used in crops, thus avoiding the contamination of natural resources due to the excess of agrochemicals in the environment (Nápolis et al., 2019).

In the present study, the maximum ideal or tolerated cow urine dose was not found for the lettuce crop, since the response was linear. There is a lack of studies in the scientific literature that indicate the ideal urine doses to be used in fertigation to promote greater lettuce plant growth. The difficulty in determining the ideal dose is due to the variation in the chemical composition of elements depending on the animal's breed, diet, physiological state, storage time, as well as on the effects of phytohormones and phenolic substances.

As for Na and Cl concentrations present in cow urine and their effects on soil, it is of fundamental importance to constantly monitor these elements at the end of each cultural cycle, and in case of elevation in the concentration of these elements, crop rotation with plants tolerant or resistant to these elements should be adopted.

Given the above, it could be concluded that the application of cow urine at dose of 20 m^3 ha^{-1} provided the best results in variable number of leaves per plant, leaf area, fresh leaf, stem, and head masses and commercial productivity. Cow urine as a supplementary fertilizer, via fertigation in organic cultivation system, is an alternative to increase lettuce productivity.

REFERENCES

Achliya G. S.; Meghre V. S.; Wadodkar, S. G.; Dorle, A. K. Antimicrobial activity of different fractions of cow urine. *Indian Journal of Natural Products*, **2004**, 20, 14-18.

Alencar, T. A. S.; Tavares, A. T.; Chaves, P. P. N.; Ferreira, T. A.; Nascimento, I. R. Efeito de intervalos de aplicação de urina bovina na produção de alface em cultivo protegido. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, **2012**, 7, 53-67.

Alvarez, V. H.; Ribeiro, A. C. Calagem. In: Ribeiro, A. C.; Guimarães, P. T. G.; Alvarez, V. H (eds). Comissão de fertilidade do solo do Estado de Minas Gerais. Recomendações para uso de corretivos e fertilizantes em Minas Gerais – 5ª Aproximação, p. 52-53, Viçosa: **1999**.

Araújo, D. L.; Oliveira, R. R.; Souto, A. G. L.; Cavalcante, L. F.; Melo Filho, J. S. Urina de vaca como atenuador da salinidade no crescimento e biomassa em plantas de berinjela. *Revista Engenharia na Agricultura*, **2019**, 27, 5, 452-461.

Dalri, A. B.; Carvalho Neto, O. F.; Mazzonetto, F.; Corbani, R. Z. Fertirrigação com vinhaça concentrada no desenvolvimento da alface. *Revista Agrogeoambiental*, **2014**, 6, 93 – 100.

Fontes, P. C. R. Sugestões de adubação para hortaliças. In: Ribeiro, A.C.; Gumarães, P. T. G.; Alvarez, V. H (eds). Comissão de fertilidade do solo do Estado de Minas Gerais. Recomendações para uso de corretivos e fertilizantes em Minas Gerais – 5ª Aproximação. p. 177. Viçosa: **1999**.

Freire, J. L. O; Silva, J. E.; Lima, J. M.; Arruda, J. A.; Rodrigues, C. R. Desempenho fitotécnico e teores clorofilianos de cultivares de alfaces crespas produzidas com fertilização à base de urina de vaca no Seridó Paraibano. *Agropecuária Científica no Semiárido*, **2016**, 12, 258-267.

Freire, M. B. G. S; Freire, J. F. Fertilidade do solo e seu manejo em solos afetados por sais. In: Novais, R. F; Alvarez V, H. V.; Barros, N, F; Fontes, R. L. F; Cantarutti, R. B; Neves, J. C. L. (eds). Fertilidade do solo. Viçosa: MG, 926-954, **2007**.

Katayama, M. Nutrição e adubação de alface, chicória e almeirão. In: Ferreira, M. E; Castellane, P. D.; Cruz, M. C. P (eds). Nutrição e adubação de hortaliças. p. 141 - 148. Piracicaba: POTAFOS, **1993**.

Lovatto; P. B.; Watthier, M.; Schiedeck, G.; Schwengber, J. E. Efeito da urina devaca como biofertilizante líquido na produção orgânica de mudas de couve (*Brassica oleracea var.acephala*). *Horticultura Brasileira*, **2011**, 29, S4571-S4577.

MAPA. Em 7 anos, triplica o número de produtores orgânicos cadastrados no ministério. **2019**. Disponível em: <https://www.gov.br/agricultura/pt-br/assuntos/noticias/em-sete-anos-triplica-o-numero-de-produtores-organicos-cadastrados-no-mapa>. Acesso em: 11/10/2020.

Monteiro, J. E. B. A.; Sentelhas, P. C. Chiavegato, E. J.; Guiselini, C.; Santiago A. V.; Prela, A. Estimação da área foliar do algodoeiro por meio de dimensões e massa das folhas. *Bragantia*, **2005**, 64, 15-24.

Nápoles, F. A. M.; Azevedo, C. A. V.; Souza, J. T. A; Souza, G. A. V. S.; Montenegro, F. T.; Oliveira, S. J. C. Growth and production of *Jatropha curcas* L. as a function of organic fertilization. *Agricultural Technology and Science Journal*, **2016**, 2, 9-15.

Nápoles, F. A. M.; Souza, J. T. A.; Azevedo, C. A. V.; Souza, G. A. V. S.; Oresca, D.; Oliveira, S. J. C. Jatropha production in function of organic fertilization with cassava water and cow urine. *Revista de Agricultura Neotropical*, **2018**, 5, 6-12.

Oliveira A. C. B.; Sediyama, M. A. N.; Pedrosa, M. W.; Garcia, N. C. P; Garcia, S. L. R. Divergência genética e descarte de variáveis em alface cultivada sob sistema hidropônico. *Acta Scientiarum Agronomy*, **2004**, 26, 211-217.

Oliveira, N. L. C.; Puiatti, M.; Santos , R. H.; Cecon, P. R. Soil and leaf fertilization of lettuce crop with cow urine. *Horticultura Brasileira*, **2009**, 27, 431-437.

Raij, B. V. Fertilidade do solo e manejo dos nutrientes. Piracicaba-SP: International Plant Nutrition Institute, **2011**.

Reboita, M. S.; Rodrigues, M.; Silva, L. F.; Alves, M. A. Aspectos Climáticos do Estado de Minas Gerais. *Revista Brasileira de Climatologia*, **2015**, 17, 222.

Salassier, B.; Soares, A. A.; Mantovani, E. C. Manual de irrigação. 6ª ed. Viçosa: Ed. UFV, 656p. **2006**.

Scalon, S. P. Q. Colheita e pós-colheita. Alface: do plantio à colheita. In Nick, C.; Borém, A. (eds). Alface: do plantio à colheita. Viçosa (MG): UFV, **2019**. p. 209.

Silva, A. G.; Cavalcante, A. C. P.; Oliveira, D. S.; Silva, M. J. R. Crescimento inicial de *Phaseolus lunatus* L. submetido a diferentes substratos orgânicos e aplicação foliar de urina de vaca. *Agropecuária Científica no Semiárido*, **2015**, 11, 131-135.

Silva, F. A. M.; Villas Boas, R. L.; Silva, R, B. Resposta da alface à adubação nitrogenada com diferentes compostos orgânicos em dois ciclos sucessivos. *Acta Scientiarum Agronomy,* **2010**, 32, 131-137.

Silva, J. C. B. Utilização de biofertilizante líquido no cultivo de alface crespa cv. Vanda. 64f. (Dissertação de mestrado) – Universidade Federal de São Carlos Centro de Ciências Agrárias, Araras, **2018**.

Souza, D. M. G.; Miranda, L. N.; Oliveira, S. A. Acidez do solo e sua correção. In: Novais, R. F; Alvarez V, H. V.; Barros, N. F.; Fontes, R. L. F.; Cantarutti, R.B.; Neves, J. C. L. (eds.). Fertilidade do solo. Viçosa: MG, **2007**. p.205-274.

Vieira, R. F.; Ramos, M. M. Fertirrigação. In: Ribeiro, C. A.; Guimarães, P. T.; Alvarez, V. H. V. (eds.). Comissão de Fertilidade do Solo do Estado de Minas Gerais Recomendações para uso de corretivos e fertilizantes em Minas Gerais – 5ª Aproximação. Viçosa: MG, **1999**. p.111-130.